Socio-economy and Related Factors Influencing Condition and Capacity of Human Excreta Disposal and Sewer Systems: A Case Study in Coastal City of Manado

Sosial-ekonomi dan Faktor-faktor yang Mempengaruhi Kondisi dan Kapasitas Pembuangan Kotoran Manusia dan Sistem Pembuangannya: Studi Kasus di Pantai Kota Manado

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Abstrak

Di Manado, limbah cair yang tidak diolah dari rumah tangga termasuk dari kakus dan dari aktivitas-aktivitas lain yang menghasilkan limbah cair seperti rumah makan, hotel, rumah sakit, tempat pembuangan akhir sampah, dan pasar dibuang langsung ke Teluk Manado melalui selokan dan sungai. Kondisi ini diperparah oleh kapasitas kakus yang tidak memadai dan saluran pembuangan limbah cair yang buruk. Untuk menilai faktor-faktor yang mempengaruhi kondisi dan kapasitas sistem pembuangan yang mungkin mengakibatkan penurunan derajat kesehatan dan lingkungan, telah dilakukan kajian deskriptif di dua kecamatan di Kota Manado yang melibatkan 304 rumah tangga di Wenang dan 300 rumah tangga di Molas. Ditemukan bahwa kebanyakan rumah tangga di kedua kecamatan tersebut telah memiliki toilet, masing-masing sebanyak 83,2% di Wenang dan 75,0% di Molas. Namun, tidak ada toilet yang berteknologi modern melainkan hanya menggunakan lubang dalam, saluran terbuka, dan sungai. Akibatnya, selama tahun 2002 kasus-kasus diare mencapai 1.250 di Wenang dan 513 di Molas. Di Molas, kejadian dematitis, gastritis, dan tifoid masing-masing mencapai 1.618. 272 dan 10 kasus. Secara statistik, kondisi dan kapasitas *septic tank* berhubungan dengan pendidikan formal dan pengetahuan mengenai limbah cair.

Kata kunci: Tinja, saluran pembuangan, limbah cair, pengelolaan limbah cair

Abstract

Untreated wastewater containing human excreta from households as well as from other wastewater-generating sources such as restaurants, hotels, hospitals, garbage disposal, and markets, is discharged directly into Manado Bay through ditches, sewers, canals, and rivers. This situation is exacerbated by inadequate capacity of human excreta disposal treatment and improper sewage system. To assess factors influencing condition and capacities of this system that may degrade human health and the environment, a descriptive study has been conducted in two districts of the City of Manado. This study involved 304 households in Wenang and 300 households in Molas district. It was found that most households in those districts have their own toilet, 83.2% and 75.0% in Wenang and Molas respectively. However, no modern technology had been adopted where open deep holes, ditches, sewers, or rivers were still being used for toilets, particularly by low income communities. During 2002 there were 513 and 1,250 diarrhoea cases reported in Molas and Wenang respectively. In Molas 1,618 dermatitis cases, 272 gastritis cases, and 10 typhoid cases were also reported. Statistically, the condition and capacity of residential septic tank were significantly correlated with the residents' level of formal education and wastewater-related knowledge.

Key words: Human excreta, sewer systems, wastewater, wastewater management.

Introduction

It has been well understood that uncontrolled discharges of wastewaters from various sources may have adverse impacts on human health and the environment. It leads to environmental deterioration and emergence of environmental-related problems such as outbreaks of wastewater-transmitted and water-borne diseases.[1] This issue has been addressed in many ways and various problem-solving approaches have been adopted in different cities and countries.

In the coastal city of Manado, North Sulawesi, untreated wastewaters from most household activities such as laundry, dishwashing, and bathing (referred to as grey water) and human excreta (referred to as blackwater)

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are discharged directly into Manado Bay through ditches, sewers, canals, and rivers. Additionally, the existing condition and capacity of the residential human excreta disposal system (i.e. septic tanks) and infrastructures and facilities of an urban sewer system are unknown. As a matter of fact, data, and information on the systems, infrastructures, and facilities of wastewater treatment are important for wastewater management of the city.

The condition and capacity of household human excreta disposal system may be associated with socio-economic characteristics and education of the residential community. To understand this association, the present study evaluated the condition and capacity of human excreta disposal and sewage system at the household level and investigated factors associated with them. This investigation hypothesized that the condition and capacity the human excreta disposal system and sewer system are correlated with socio-economic characteristics such as monthly household income, house ownership status, and education level as well as community's knowledge regarding the environment. Based on the study results, mitigation of wastewater problems and management are discussed in a broad sense.

Method

The present study was conducted in Molas and Wenang districts, with Tanjung Batu sub-districts of Wanea district was selected as reference for comparison, in the city of Manado from August 2002 to June 2003. Residential house (permanent, semi-permanent, or other) was assigned as the basic sample unit to design sampling method, assuming that every house has its own toilet with septic tank as human excreta disposal system. Using the Slovin formula, from 300 houses in Molas and 304 houses in Wenang only 163 and 169 houses in Molas and Wenang, respectively, were observed for evaluating the capacity of human excreta disposal system.[2] Sewer system was evaluated using the same sample unit as for human excreta disposal system evaluation. A set of evaluation criteria for both human excreta disposal system condition and capacity and sewage system was developed as presented in Table 1. Capacity criterion of septic tank was based on the number of person using the toilet. Every two household occupants equals 1.420 L of capacity.[3]

Data on socio-economic characteristics (age, employment, monthly income, number of family dependant, house ownership, and education level) and knowledge about environment were collected by household survey at family level using structured questionnaire. One adult male or female per household was selected randomly as respondent. The questionnaire addressed two topics consisting of several focus questions. The first topic was about knowledge of general issues on environment and pollution covering four focus questions i.e. 1) definition of environment and pollution, 2) pollution in the coastal area, 3) toxic substances causing pollution, and 4) reason of toilet use. The second topic was about knowledge about environmental issues related to wastewater covering three focus questions i.e. 1) pollution of potable water due to wastewater discharge, 2) wastewater discharge causing disease, and 3) diseases caused by wastewater from toilets. Chi-square (c^2)-test with 0,5% significance level was applied to analyze the significance of the collected data, while Pearson correlation coefficient was employed using the SPSS computer program to test the linier correlation of the socio-economic characteristics and the knowledge about environment with the condition

Table 1. Evaluation Criteria for Condition and Capacity of Household Human Excreta Disposal and Sewage System

Criteria	Household Septic Tank		Condition of Sewer System
	Condition	Capacity[a]	
Very poor	leaking to sewer		With or without concrete/cement, littering by solid waste, no running water
Poor	open hole	<1.420 L (< 5 years of use)	No concrete/cement, littering by solid waste, running water
Adequate	closed hole, no concrete/cement	1.420 – 1.770 L (5 to 10 years of use)	With or without concrete/cement, no littering by solid waste, no running water
Good	closed hole, concrete/cement, one compartment	>1.770 L (10 to 15 years of use)	With or without concrete/cement, with or without littering by solid waste, running water
Very good	closed hole, with concrete/cement, two compartments		

[a]Based on standard of 1.420-L septic tank capacity for one bedroom,[2] consisting of two persons.

Table 2. Condition of Septic Tank and Sewer System and Capacity of Septic Tanks in Selected Houses

Criteria	Septic Tank Condition		Sewage System Condition		Septic Tank Capacity			
					Wenang (n = 169)		Molas (n = 163)	
	Wenang (n = 304)	Molas (n = 300)	Wenang (n = 304)	Molas (n = 300)	Volume/ Bedroom	Volume/ Person	Volume/ Bedroom	Volume/ Person
Very poor	12,2	4,3	8,2	2,3	NA	NA	NA	NA
Poor	0,3	0,3	5,9	3,0	55,1	45,0	35,0	37,4
Adequate	0,0	0,7	2,0	3,3	11,8	11,2	10,4	9,8
Good	15,1	23,3	4,9	38,0	33,1	43,9	54,6	52,8
Very good	30,9	37,0	62,2	52,7	NA	NA	NA	NA
NI	24,7	9,3	16,8	0,7	NA	NA	NA	NA
All criteria	83,2	75,0	100,0	100,0	100,0	100,0	100,0	100,0

NA = not applicable. NI = no information

Table 3. Descriptive Statistic of Socio-Economy and Education Level

Variables	Catagory	Wenang (n =304) (%)	Molas (n =300) (%)
Age group (years)	20-60	68,1	79,7
	>60	17,4	16,0
	No information	14,5	4,3
Employment	Private company	70,7	74,7
	Civil Servant	26,0	21,7
	Unemployed	1,6	No data
	No information	1,6	3,7
Income per month[a]	<Rp. 1.000.000	64,5	68,7
	>Rp1.000.000	16,2	15,6
	No information	19,4	15,7
Number of dependants in a household	0-2	36,8	28,7
	3-4	36,8	40,0
	5-6	13,5	18,3
	7-8	2,0	6,0
	9-10	1,0	1,7
	No information	9,9	0,3
House ownership status	Owner	81,6	82,7
	Family	0,0	4,7
	Rent	18,4	12,7
	No information	0,0	0,0
Level of formal education	Primary school	2,6	13,3
	Secondary school	8,2	19,0
	High school	61,5	53,7
	University graduate	27,3	13,7
	No information	0,3	0,3

[a]Current rate Rp8.500 per one US$

and capacity of human excrete disposal system and sewage system.

Results

Availability, Condition, and Capacity of Septic Tank and Sewer System

The availability of septic tank as human excreta disposal treatment system per household unit in Molas (75,0%), Wenang (83,2%), and Wanea districts (85,3%), while condition and capacity of septic tank and sewer system are presented in Table 2. Criteria for septic tank capacity were 'poor', 'adequate', and 'good' only, while 'very poor' and 'very good' were not applicable. Besides, data on septic tank availability in Wanea was not collected directly by field survey but obtained indirectly from secondary source available at PPLH-SDA. Of the households surveyed, no house has appropriate sewer system but uses open channel only.

Socio-economy and Education Level

Proportion of the socio-economic characteristics and

Tabel 4. Statistical Summary of Residents' Knowledge about General Issues on Environment and Wastewater-related Issues

Knowledge	Catagories	Molas (n dan %)	Wenang (n dan %)	*P value*	OR
Environment and pollution terminology	Know	103 (34,0)	181 (60,3)	0,0001	0,34
	Do not know	201 (66,0)	119 (39,2)		
Pollution in coastal area	Know	124 (40,8)	135 (45,0)	0,295	0,84
	Do not know	180 (59,2)	165 (55,0)		
Toxic pollutant	Know	63 (20,7)	125 (41,7)[a]	0,000	0,36
	Do not know	241 (79,3)	174 (58,0)		
Reason of toilet use	Know	282 (93,0)	290 (96,7)	0,032	0,44
	Do not know	22 (7,0)	10 (3,3)		
Pollution of potable water by wastewater discharge	Know	91 (29,9)	134 (44,7)	0,0001	0,53
	Do not know	213 (70,1)	166 (55,3)		
Wastewater discharge causes disease	Know	299 (98,3)	298 (99,3)	0,261	0,40
	Do not know	5 (1,7)	2 (0,7)		
Diseases caused by human excreta from toilet	Know	236 (77,6)	257 (85,7)	0,010	0,58
	Do not know	68 (22,4)	43 (14,3)		

[a]One respondent did not answer this focus question, leaving one missing data (0,3%)

education level of Wenang and Molas residents are summarized in Table 3. It consists of adult age group, employment, monthly income, number of family dependant, house ownership status, and formal education level.

Knowledge about Environmental Issues

Residents' knowledge about environmental issues in Wenang and Molas is summarized in Table 4. It describes differences in knowledge level on environmental issues among residents in the two districts as shown by p value (aggregated value) for each focus question.

Discussion

Condition and Capacity of Septic Tank

In general, most constructions of either residential or commercial buildings must have their own toilet with a septic tank as standard human excreta disposal system. A disposal system for a cluster of homes is set up to serve several households in a residential area. However, in the districts of the present study no modern system with appropriate technology has been adopted to discharge grey water and blackwater properly. There was only conventional disposal systems with one or two septic tanks using gravity method. Besides, for low income households, a deep hole, ditch, or river were still used for toilet. This disposal mode is the main source of wastewater in the city where condition of septic tanks was poor and its capacity was inadequate.

As presented in Table 2, the condition of septic tanks varied from very good to very poor. The 'very poor' (i.e the septic tank is leaking into residential wells and sewers) and the 'poor' (i.e. using an open hole) septic tanks were observed in both districts as well as the 'adequate', 'good', and 'very good' categories. In this study, a condition is categorised as 'very good' if the septic tanks consist of two compartments, have a closed hole covered with a lid, and are made of concrete or cement.

There were also houses without septic tank facilities, accounting for 16,8%; 25,0%; and 14,7% in Wenang, Molas, and Wanea districts, respectively. In this case, the households probably use the communal septic tank or sewers, canals, or rivers to directly discharge the contents from their toilets. It was observed in the Molas district that most of the public or communally-used toilets have septic tanks in poor condition. This was probably due to a lack of management, especially a lack of finances for maintenance, and the lack of awareness of the users to keep them clean.

Besides these conditions, most of the septic tanks of the city's houses were categorized as poor, regardless their capacity. The capacity of septic tanks is considered to relate to non-technical aspect such as the number of persons using the facility; while the presence of the septic tank is considered to relate to available space of at least 2 x 2 m. One standard to measure the appropriate capacity of a septic tank is to consider that every two household occupants equivalent with 1419,38 litres of wastewater.[3]

Condition of Sewer

None of the houses observed in the present study have grey water treatment systems. Seemingly, the residents did not consider the wastewater from bathrooms, kitchens, and other sources except septic tanks as causes of environmental problems. So, they did not build such treatment facilities to discharge their wastewater. The sewer at the household level was an open channel system. Table 3 shows the condition of infrastructures and faci-

Table 5. Pearson's Correlation Coefficient (PC) by Using The Bivariate Correlations Procedure

Variables	Capacity of Septic Tank			Condition of Septic Tank		
	PC	P value	N	PC	P value	N
Socio-economic aspects						
Household Income per Month	-0,091	0,99	332	-0,21	0,699	332
Level of Education	-0,044	0,424	332	+ 0,103	0,062	332
House Status	-0,022	0,689	332	-0,047	0,394	332
Community's environmental knowledge						
Knowledge on general issue about environment & pollution	-0,039	0,482	332	-0,033	0,551	332
Knowledge on environmental issue related to wastewater	+0,017	0,761	332	-0,003	0,949	332

Table 6. Number of Cases of Infectious Diseases in Manado City in 2002[a]

Districts (Sub-districts)	Diarrhea	Dermatitis	Gastritis	Typhoid
Molas (Tuminting)	513 (58[b]/48[c])	1.618	196[b]/272[c]	10[b,c]
Wenang (Tikala Baru)	1.250	NA	NA	NA
Sario (Ranotana)	27	253	NA	NA
Malalayang (Bahu)	288	777	NA	NA
City Hospital (total)	1.075	2.725	NA	NA

[a] The data were collected at Puskesmas (community health centre) in each district.
[b] Collected during October-December 2002.
[c] collected during January-April 2003.
NA = not available.

lities of sewer systems in Wenang and Molas districts. It varied from very poor to very good conditions. In Wenang and Molas, the very poor conditions were only found in 8,2% and 2,3% of the households, respectively. The poor condition of the sewer systems may block the flows the household wastewater discharges to ditches and canals resulting in wastewater puddles. It is certainly unhygienic and may promote bad odors and provide breeding places for rats, mosquitoes, and other insects. In contrast, the very good conditions comprised as much 62,2% and 52,7%, respectively. Very good condition of sewer system refers to concrete or cement construction, no littering of solid waste, and running water (Look Table 1).

Residents' Knowledge about Environmental Issues

Table 4 shows the respondents level of knowledge regarding general environmental issues and wastewater-related issues. Pearson's correlation coefficient (PC) of socio-economic characteristics with the community's environmental knowledge and with the condition and capacity of residential septic tanks are negative (Look Table 5). Oppositely, PC of the septic tank condition with the level of education and the septic tank capacity with the knowledge on environmental issues related to wastewater are positive. However, these correlations were statistically not significant (p>0,05). It can be said that the condition of residential septic tanks was correlated with the level of education, while the capacity of the septic tanks was correlated with the knowledge of environmental issues related to wastewater.

A small number of the houses has septic tanks in very poor and poor conditions with about 12% in Wenang, 4% in Molas. In both districts, about 50% septic tank capacity was in poor category. But, this situation was not correlated with the monthly household income and the house ownership status as indicated by negative PC in Table 5. It can be said that, although improving the condition and capacity of septic tanks needs higher costs, the higher income was, however not the guarantee that their septic tank's condition and capacity would be better. Besides, even though most of the houses in the study sites were owned by the residents themselves (82,7% in Molas and 81,6% in Wenang), this was also not the guarantee for better condition and capacity of their septic tank.

Seemingly, other factors than those of the socio-economic aspects mentioned above may have influenced the septic tank condition and capacity. One possible factor might be a direction from the city's government to improve their own wastewater facilities. However, the community concern regarding the environmental conditions

and impacts was voiced in a positive note.[4,5]

Wastewater Impact and Management

Since the rivers are used for activities such as washing, bathing, fishing, and fish cage culture, the discharge of untreated wastewater poses a threat to community health. This was confirmed by the number of cases of wastewater-transmitted diseases. Infectious diseases in some districts in the City Manado mostly diarrhea and dermatitis which might be associated with untreated wastewater (Look Table 6).

Facing the problems mentioned above, wastewater management is urgently needed in order to prevent and mitigate the wastewater impacts in addition to the establishment of pollution monitoring programs.[6-8] From this point of view, wastewater problem solving measures applied in a coastal area should be put into a more integrated context of management than the on-site treatment system only. As so many different stakeholders, types, sources, and impacts of pollutants are involved, the wastewater aspect should be evaluated and analyzed from an integrated point of view, taking all parts of the system that is the sewer system, wastewater treatment plant, and receiving waters into consideration.[9] In this case, communities (including private sectors) and governments should combine their efforts and resources into an integrated management measure.[10] This could be an option to increase participation for conducting wastewater management. However, institutional and political factors could be barriers to implementing this issue option.[11]

A certain model of wastewater management system could be applied by a city of either centralized or decentralized system. In previous times, a centralized system was thought to be easier to be planned and managed. But nowadays, based on some experiences, such a system has deficiencies, in which it is particularly poor at reaching peri-urban areas and, therefore, a decentralized system is adopted as appropriate for such areas.[12] According to Parkinson and Tayler,[12] decentralized systems are more compatible with decentralized approaches to urban management than centralized systems.

As wastewater treatment system is a component of wastewater management, sustainability of wastewater management is important.[6] Some techniques could be applied ranging from direct wastewater treatment system to a reused wastewater system.[6,13-16] With this respect, James and Niemczynowicz,[17] suggested two possible scenarios for a wastewater treatment system.[18] Firstly, the high technology option with continuation, development and complementation of present technology. Secondly, low-cost and low-energy solutions based on the application of biological systems and the recycling of resources. Compared with the first, the second scenario will lead to a less vulnerable and more sustainable society. Based on Niemczynowicz's action plan, another two scenarios can be suggested: a centralized wastewater treatment system with off-site concentration and storage and decentralized wastewater treatment system with on-site concentration and storage.

Conclusion

In the coastal city of Manado, no modern system with proper technology has been adopted for the residential treatment systems. There were only conventional septic tanks using gravity method used by most city residents. Besides, for low income households, a deep hole, ditch, or river are still used for toilet. The latter practices are considered as the main source of wastewater in the city where the condition of the toilet and septic tank systems was poor with inadequate capacity. The condition of residential septic tanks was correlated with the level of education, while the capacity of the septic tanks was correlated with the community's knowledge on environmental issues related to wastewater.

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